REMARKS

In view of the above amendments, Claims 1-3, 6-8, 11-13, 16-18, 21, and 24 are pending in the present application. Claims 1, 11, 16 and 24 are presented in independent form. Claims 4, 5, 9, 10, 14, 15, 19, 20, 22, and 23 are cancelled.

Claim 1 is amended to include the features of Claims 4 and 5. Accordingly, Claims 4 and 5 are cancelled. Claim 8 is amended to include the features of Claims 9 and 10. Accordingly, Claims 9 and 10 are cancelled. Claim 11 is amended to include the features of Claims 14 and 15. Accordingly, Claims 14 and 15 are cancelled.

Claim 16 is amended to include the features of Claims 19 and 20. Accordingly, Claims 19 and 20 are cancelled. Claim 21 is amended to include the features of Claims 22 and 23. Accordingly, Claims 22 and 23 are cancelled. Claim 24 is amended to set forth minor modifications to the claim language set forth therein for clarification purposes. Applicant respectfully submits that no new matter is presented by these amendments.

The 35 U.S.C. §103(a) Rejections

In the Office Action, Claims 1-3, 8-13, 16-18 and 21-24 stand rejected under 35 U.S.C. §103(a) as obvious in view of an article titled "Linear N-Point Camera Pose Determination" by Long Quan et al. (herein "Quan") and U.S. Patent Publication No. 2003/0044048 (hereinafter "Zhang"). In addition, Claims 4, 6-7, 14 and 19 stand rejected as obvious in view of the combination of Quan, Zhang, and an article titled "Motion from Point Matches: Multiplicity of Solutions," by O. Faugeras et al. (herein "Faugeras"). Finally, Claims 5, 15 and 20 stand rejected as obvious over the combination of Quan, Zhang, and an article titled "3D Head Tracking Using Motion Adaptive Texture-Mapping," by Brown (herein "Brown").

It is well-established that in order to establish a *prima facie* case of obviousness, there must be some suggestion or motivation, either in the references themselves or in the knowledge

generally available to one of ordinary skill in the art, to modify the reference or to combine reference teachings. (*See* Manual of Patent Examining Procedure (MPEP) §2142). Furthermore, a *prima facie* case of obviousness requires that the prior art references, considered individually or in combination, must teach or suggest all of the Applicant's claim limitations. (*Id.*) For at least the reasons set forth below, Applicant respectfully submits that the cited combination of references fails to teach or suggest each and every element of Claims 1-3, 6-8, 11-13, 16-18, 21 and 24.

The present invention relates to a method and system for determining the relative camera pose of at least two cameras based on related point correspondences. (Applicant's Published Appl. No. 2004/0227820, Abstract, paragraph [0021]). According to the present invention, a plurality of five point correspondences are obtained from a pair of images from two distinct unknown viewpoints, and at least one hypothesis (i.e., the relative pose or orientation of the cameras) is generated for each of the five point correspondences.

The at least one hypothesis is generated by obtaining a tenth degree polynomial wherein the ten solutions to the classic five point correspondence problem correspond to the ten roots of the polynomial. (Applicant's Published Appl. No. 2004/0227820, paragraph [0005]). In the prior art, it has proven to be very difficult to determine the coefficients of the tenth degree polynomial. For example, some conventional systems derive the coefficients by finding all the intersections between two sextic curves, which is a time-consuming, inefficient process. (Applicant's Published Appl. No. 2004/0227820, paragraph [0005]).

As acknowledged by the Examiner, "neither Quan or Zhang expressly disclose...the generation of at least one hypothesis by generating a tenth degree polynomial." (Office Action, page 6). To cure this deficiency, the Office Action relies on Faugeras, stating that "Faugeras discloses a method of finding camera motions compatible with a given set of

[i]mage correspondences (see abstract) that includes generating a hypothesis by generating a tenth degree polynomial." (Office Action, page 6). In support of this conclusion, the Examiner argues that Faugeras teaches "that 5 image correspondences are used and 10 solutions are obtained, see page 237, [p][009], lines 1-11." (Office Action, page 6).

However, the section of Faugeras cited by the Examiner relates to a conventional method of determining two sextic curves and obtaining solutions based on the intersections of the curves. (Faugeras, page 237, paragraphs 1-4 in section 6.1). This approach results in as many as 36 solutions and the 10 valid solutions are obtained by eliminating the 26 "impossible solutions", in a complex and inefficient process detailed in section 5.5 of Faugeras. (Faugeras, pages 236-237, section 5.5). It is only as a result of this elimination process that Faugeras arrives at a tenth degree polynomial. This approach is in stark contrast to the method for directly deriving the tenth degree polynomial recited in the claims of the present application.

Furthermore, although Faugeras lists the properties of the essential matrix, there is no teaching or suggestion in Faugeras of using the essential matrix to generate the tenth degree polynomial, as set forth in the claims of the present application.

Claims 8, 21 and 24 of the present application relate to a preemptive scoring process based on a random sample consensus scheme (RANSAC) paradigm, wherein a solution to the relative pose estimation based on a plurality of point correspondences across two viewpoints is achieved. (U.S. Publication No. 2004/0227820, paragraph [0079]).

In general, the RANSAC process is a known mechanism configured to deal with outliers (i.e., wrong matches) in the data, involving the following steps: 1) generating solution candidates (i.e., hypotheses) based on randomly sampling minimal subsets from the dataset; 2) testing each of these hypotheses against the whole dataset; and 3) selecting the best candidate that most closely matches the underlying dataset. However, the conventional RANSAC

approach is inefficient when a large number of 5-point samples are drawn from a dataset. For example, if 1000 point correspondences heavily contaminated with outliers are drawn, and the standard RANSAC approach selects 5 point matches at a time, then 512 hypotheses are generated. Then, according to the conventional RANSAC method, each hypothesis is tested on the entire dataset, resulting in 512,000 operations (512 x 1000). Clearly this approach requires burdensome processing and is inefficient in identify the optimal hypothesis.

In contrast, the process claimed in the present application preemptively detects "bad" hypotheses (i.e., the hypotheses based on 5-point matches which were in turn based on outliers), prior to comparison with the dataset. This greatly reduces the number operations that are required in order to identify the best hypothesis. According to the example set forth above, using the approach claimed in the present application, initially 100 points from the original set of 1000 may be used to score all of the 512 hypotheses, resulting in 51,200 operations (512 x 100). Then, the hypotheses are scored, and a portion of the hypotheses (e.g., one half) that perform the worst are discarded. Next, another set of 100 points are used to score the remaining 256 hypotheses, resulting in 25,600 operations. This process continues iteratively and, in this example, results in 102,200 operations (512 + 256 + 128 + 64 32 + 16 + 8 + 4 + 2). When compared to the conventional RANSAC method, a 5-fold reduction in the required number of computations is realized.

In the Office Action, the Examiner relies on Zhang in rejecting Claims 8-10 and 21-24, stating that the local bundle adjustment processing described in paragraphs [0051]-[0055] of Zhang is a "further process," and teaches the preemptive scoring process of the present invention. However, the local bundle adjustment process described in Zhang is known in the art as a stand-alone process which is applied after either a preemptive or standard RANSAC process is completed. In Zhang, after the 'optimal' or 'winning' hypotheses is obtained via the

application of a conventional RANSAC method, the local bundle adjustment process is applied. The local bundle adjustment is an iterative refinement process used to further improve the pose hypothesis generated by the RANSAC method by enforcing local constraints imposed by the point correspondences across these set of frames. In this regard, Zhang provides a method for refining a winning hypothesis, and does not relate to scoring a number of hypotheses. In contrast, Claims 8, 21, and 24, as amended call for a process for scoring the hypotheses generated via the five-point method of the present application to help determine/select a 'winning' hypothesis.

For at least the reasons set forth above, Applicant submits that Quan, Zhang, Brown, and Faugeras, considered alone or in combination, fail to teach or suggest the invention as claimed in amended Claims 1-3, 6-8, 11-13, 16-18, 21, and 24. As such, all pending claims are believed to be in condition for allowance. Favorable reconsideration in this regard is earnestly solicited.

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